

Aerial photographic analysis of riparian vegetation growth and channel change at Canyon de Chelly National Monument, Arizona, 1935-2004

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Abstract. Aerial photographs over the past 70 years show that a profound alteration in the channels of Canyon de Chelly National Monument has coincided with the establishment and expansion of riparian vegetation, in particular invasive tamarisk (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*). Rectification of air photos, using a GIS, enabled detailed mapping of the extent of vegetation in the canyon bottom, and analysis of stream channel planform geometry for each photo set. Photo sets from 1934, 1964, 1975, 1981, 1989, and 2004 were used to track changes in vegetation and channel morphology through time. In 1934, scattered riparian vegetation, including cottonwood (*Populus* spp.) and willow (*Salix* spp.), covered <1% of the canyon bottom. The photo sets from 1964 and 1975 are very similar and show an increase in vegetation cover since 1935, almost exclusively cottonwood, while the channel remains wide and unincised. Most increases in percent cover occurred where the channel approaches agricultural fields. The Civilian Conservation Corps was active in Canyon de Chelly during the 1930s and 1940s, installing check dams and spider jetties and planting vegetation in order to protect the agricultural fields, and these activities likely influenced the distribution and degree of vegetation growth. During the 1980s vegetation coverage expanded rapidly into the formerly active channel, with photo-based measurements showing a simultaneous channel narrowing. The photos also indicate that most new vegetation coverage identified in the 1989 photos was comprised of tamarisk or Russian olive. Potential climatic and water management influences are being investigated as potential triggers for this rapid vegetation coverage expansion. By 2004, the full length of the channel was lined with a riparian vegetation belt, with vegetation covering as much as 45% of the canyon bottom in some 1 km long study reaches. However, the width of the riparian belt was spatially discontinuous, with other study reaches having only 5% coverage of the canyon bottom. Also, the 2004 photos indicate 80% of the study area was a single threaded channel, with an average width of 5m, and with dense Russian olive and tamarisk stands filling most of the former wash. The remaining 20% of the canyon, primarily in the lowermost reaches, remained a wide sandy wash, lined with stands of woody vegetation. Additionally, some of the narrowed reaches of the channel have become deeply incised, as much as 3 m below the 1964 floodplain, as indicated by persistent cottonwood individuals. Quantitative analysis of incision through time was not possible using air photos, however field work indicates that incision was still very active in 2005. Although vegetation establishment is ubiquitous in Canyon de Chelly, some areas remain unincised, and the degree of incision varies irregularly downstream.